Fluid forces exerted on slender cylinders in a flow

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The knowledge of the fluid forces exerted upon a laterally oscillating slender structures prensents applications in many fields, such as the vibrations of fuel assemblies or heat-exchangers in the nuclear industry [1], the stability of towed structures in water [2], the dynamical behaviour of risers and mooring cables in the offshore industry [3], or animal locaomotion [4]. The axial flow-induced damping on a cylinder undergoing small lateral oscillations can be quantified within the framework of the quasi-static assumption. In this framework, it is assumed that the damping exerted on an oscillatory structure perpendicularly to the flow depends linearly to the normal component of the force exerted on the stationnary yawed structure in the same flow (see Fig. 1). At small values of the yaw anlge, assuming that only friction contributes the normal force, only approximate or asymptotic representations have been proposed in the literature [4, 5]. But this contribution of friction is generally lower than that necessary to correctly predict damping forces. An adjustement of coefficients is then generally performed empirically.

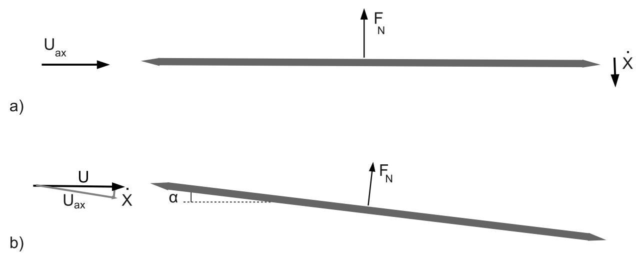

Figure 1: Equivalence between a slender structure translating perpendicularly to a flow (a) and the same stationnary structure in incidence in the same flow (b).

Our experiments [6] and numerical simulations [6, 7] on slender cylinders at high Reynolds numbers show that the normal force is dominated by the lift component and not by the drag. Actually the drag contribution is only 10% of the normal force, which renders questionnable the use of Taylor's assumption for the comprehension of the damping origin. Pressure measurements show that the lift force is originated by the pressure surrounding the cylinder, and is dominated by the front pressure at the dividing streamline behaving linearly with the yaw angle.

References

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